US009093792B2

(12) **United States Patent**
Shiratori et al.

(10) **Patent No.: US 9,093,792 B2**
(45) **Date of Patent: Jul. 28, 2015**

(54) **CONNECTOR AND SIGNAL TRANSMISSION METHOD USING THE SAME**

(71) Applicant: **Japan Aviation Electronics Industry, Limited**, Tokyo (JP)

(72) Inventors: **Masayuki Shiratori**, Tokyo (JP); **Shuichi Aihara**, Tokyo (JP); **Masayuki Katayanagi**, Tokyo (JP); **Osamu Hashiguchi**, Tokyo (JP)

(73) Assignee: **Japan Aviation Electronics Industry, Limited**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 5 days.

(21) Appl. No.: **14/069,648**

(22) Filed: **Nov. 1, 2013**

(65) **Prior Publication Data**

US 2014/0235108 A1 Aug. 21, 2014

(30) **Foreign Application Priority Data**

Feb. 18, 2013 (JP) 2013-029400

(51) **Int. Cl.**

H01R 4/66	(2006.01)
H01R 13/652	(2006.01)
H01R 13/6471	(2011.01)
H01R 13/6474	(2011.01)
H01R 12/57	(2011.01)
H01R 12/72	(2011.01)

(52) **U.S. Cl.**

CPC ***H01R 13/652*** (2013.01); ***H01R 13/6471*** (2013.01); ***H01R 13/6474*** (2013.01); *H01R 12/57* (2013.01); *H01R 12/724* (2013.01); *H01R 2201/06* (2013.01)

(58) **Field of Classification Search**

CPC .. H01R 23/7073; H01R 23/688; H01R 43/16; H01R 23/005

USPC 439/79, 101, 108, 660, 885, 941

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,303,410 B2 * 12/2007 Saito 439/108
7,448,884 B2 * 11/2008 Kato et al. 439/108

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2005-149770 A 6/2005
JP 3990355 B2 7/2007

(Continued)

OTHER PUBLICATIONS

Korean Office Action dated Feb. 17, 2015 in KR 10-2013-0141199 with English translation of relevant parts.

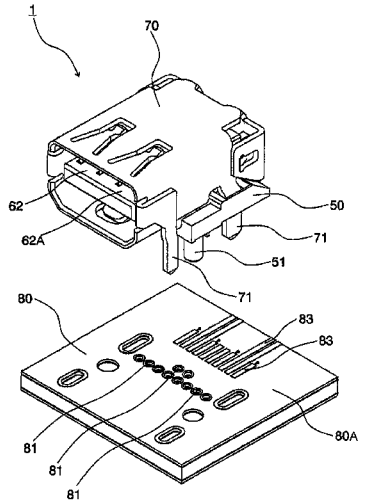
Primary Examiner — Thanh Tam Le

(74) *Attorney, Agent, or Firm* — Collard & Roe, P.C.

(57) **ABSTRACT**

A connector has a plurality of high-speed differential signal lanes each of which includes two first contacts for high-speed differential signal transmission and two ground contacts. A second contact which does not belong to the high-speed differential signal lanes is arranged between the high-speed differential signal lanes. On a first connection side for connection with a connecting object, contacting portions of the contacts are arranged in a single row at a distance from one another. On a second connection side for connection with a mounting object, terminal portions of the first contacts and terminal portions of the ground contacts are arranged in a first row at a distance wider than that between the contacting portions while a terminal portion of the second contact is arranged in a second row.

16 Claims, 9 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

7,708,601	B2 *	5/2010	Tanaka	439/660
8,591,272	B2 *	11/2013	Shiratori et al.	439/885
8,894,451	B2 *	11/2014	Shiratori et al.	439/885
2005/0101163	A1	5/2005	Obikane et al.	
2008/0014803	A1	1/2008	Kato et al.	
2010/0330848	A1	12/2010	Kondo et al.	

FOREIGN PATENT DOCUMENTS

JP	4439540	B2	3/2010
KR	10-2011-0001866	A	1/2011
WO	02/101883	A2	12/2002

* cited by examiner

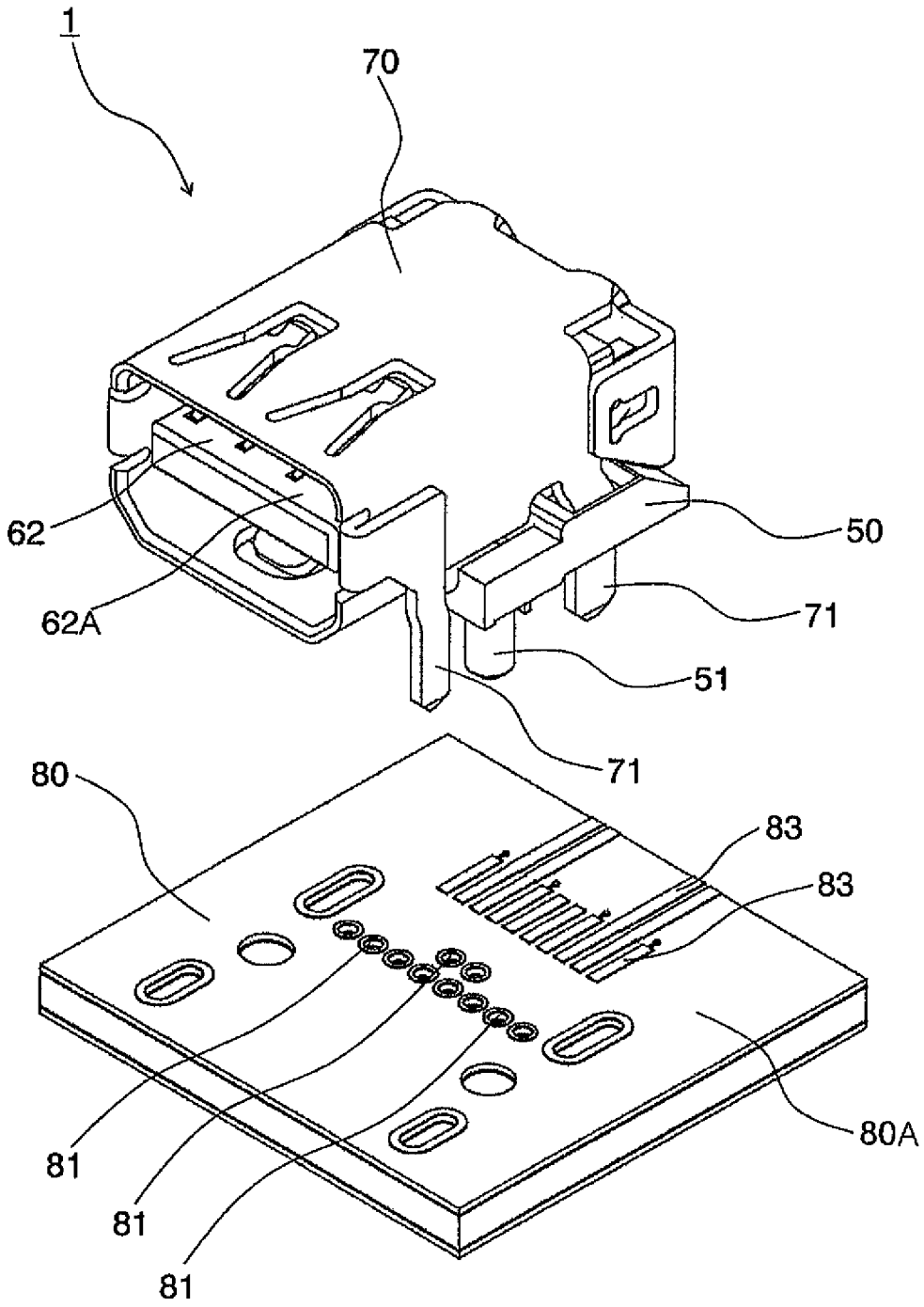


FIG. 1

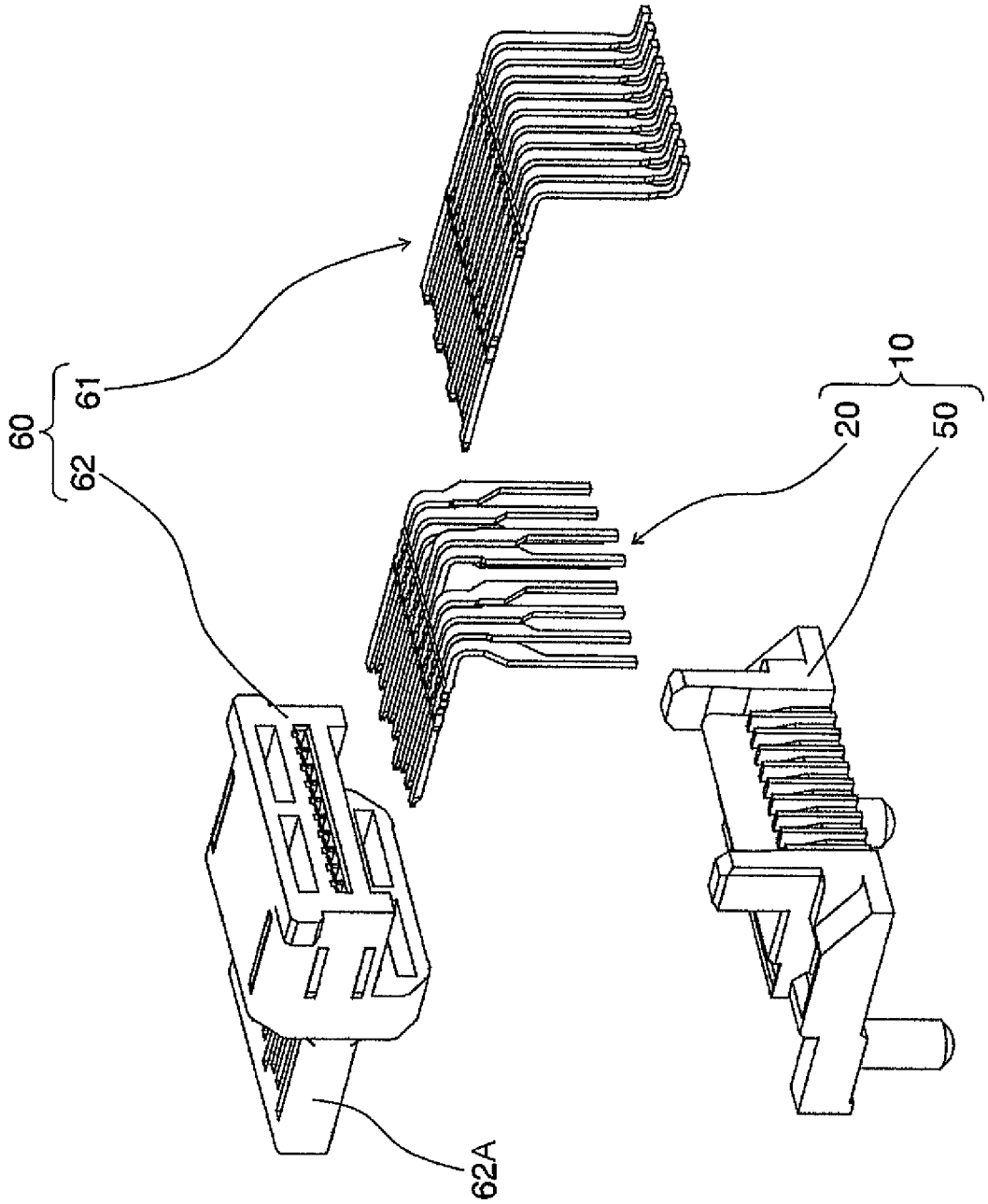
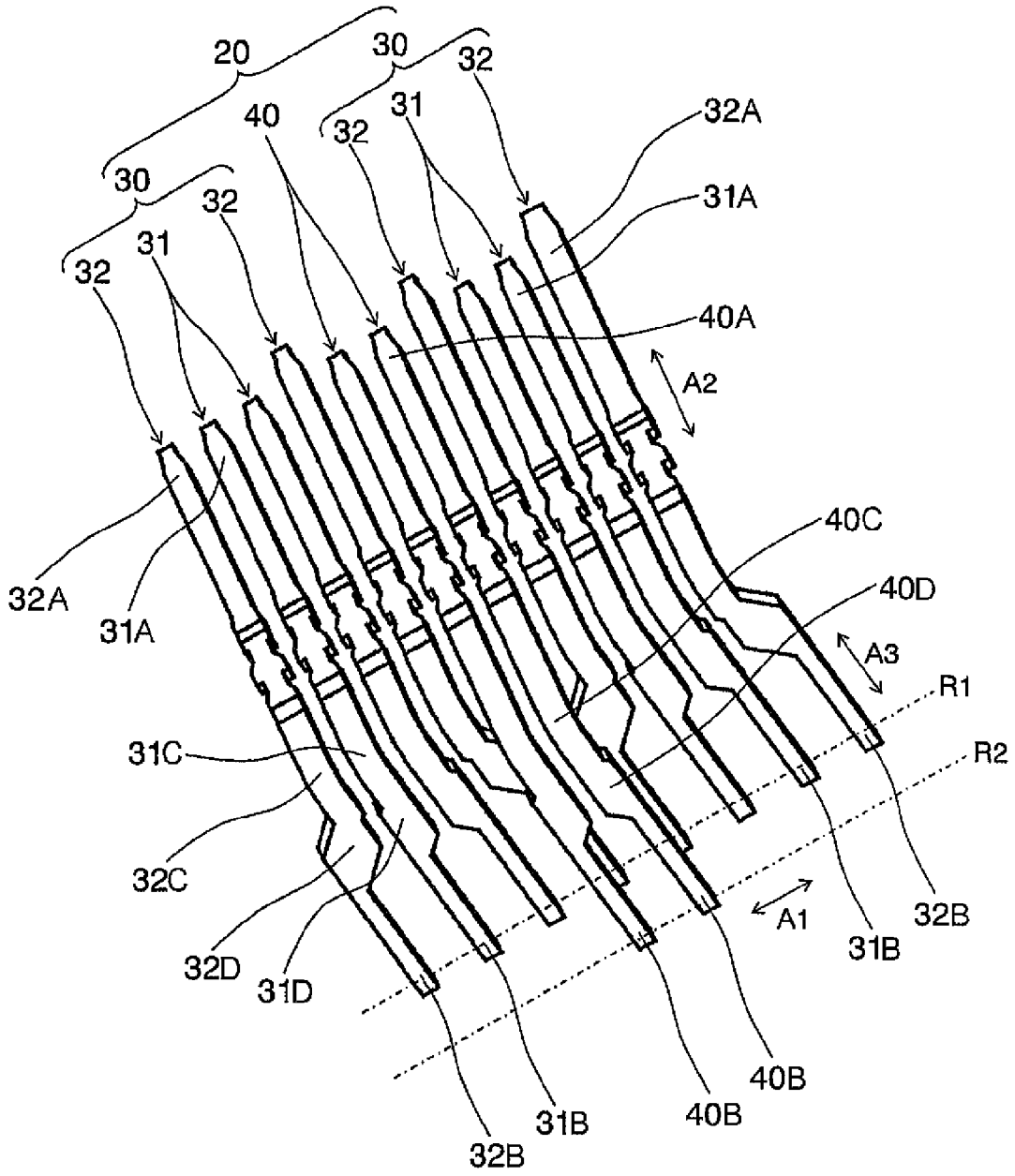


FIG. 2


20
30
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31
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32A
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40A
A2
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40C
40D
A3
R1
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A1
32B
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32D
31D
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40B
31B
32B

FIG. 3

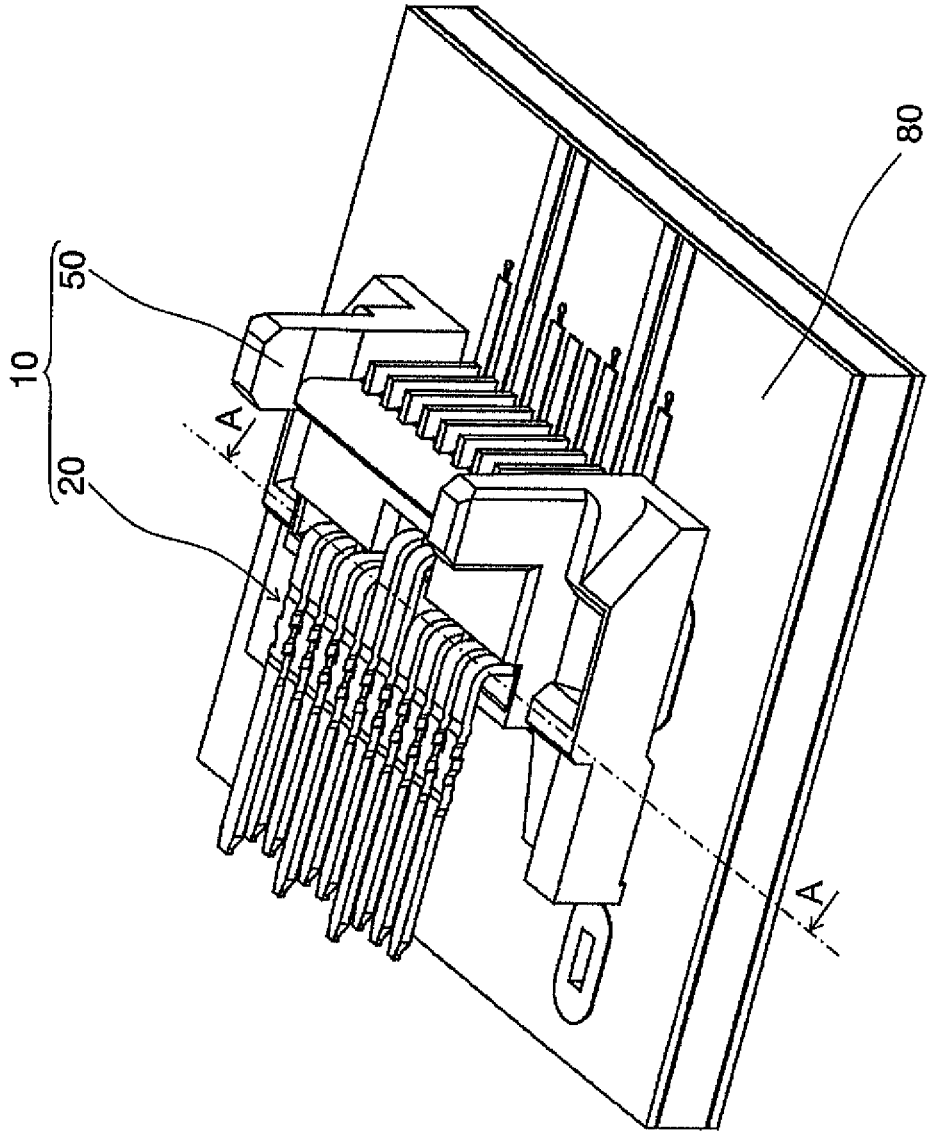

FIG. 4

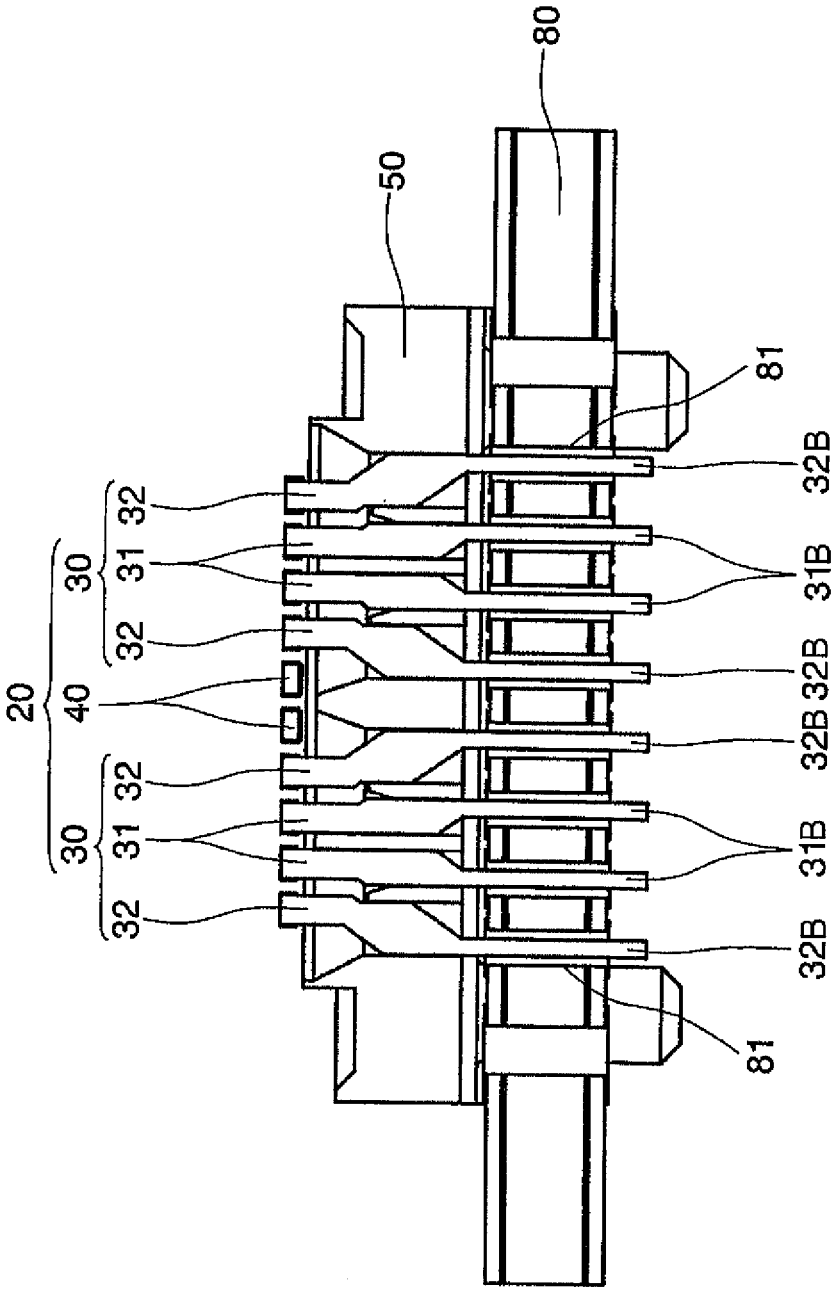

FIG. 5

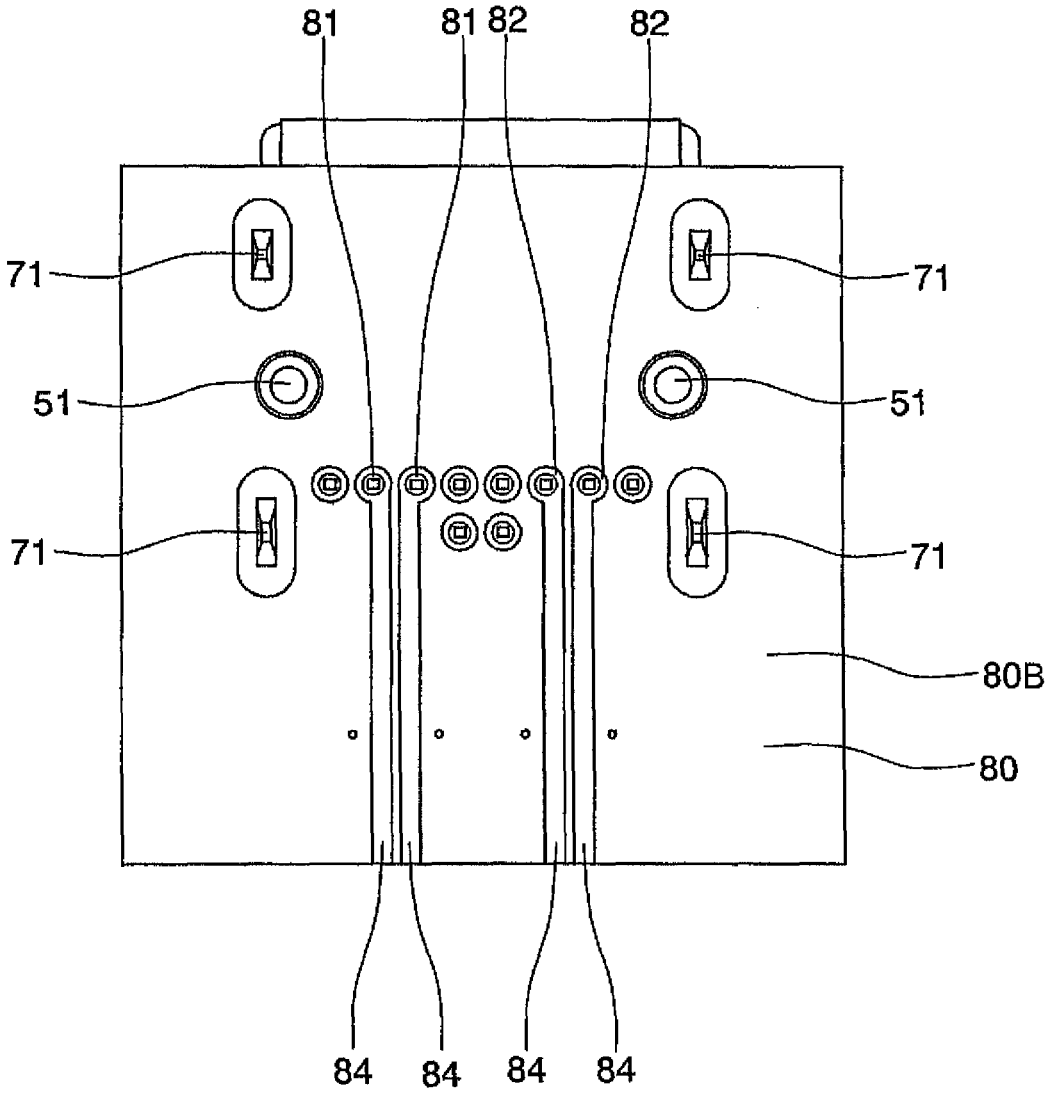

FIG.6

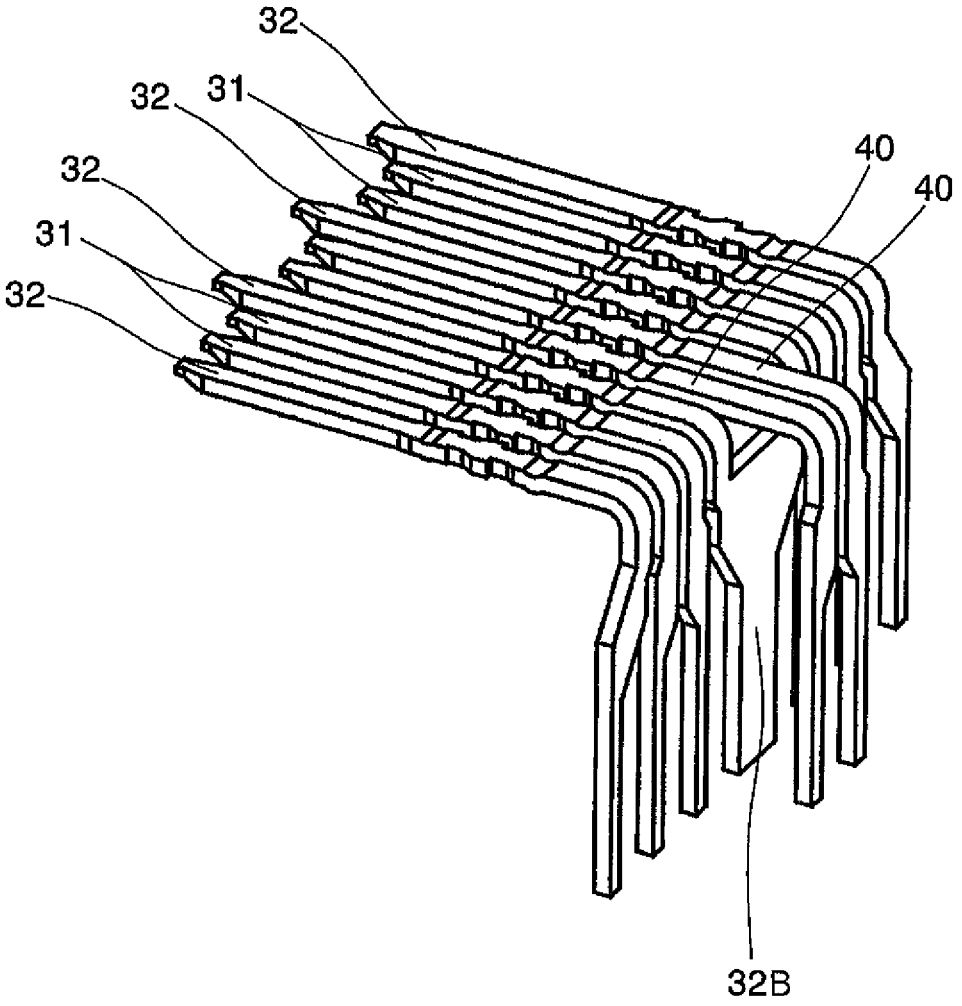

FIG. 7

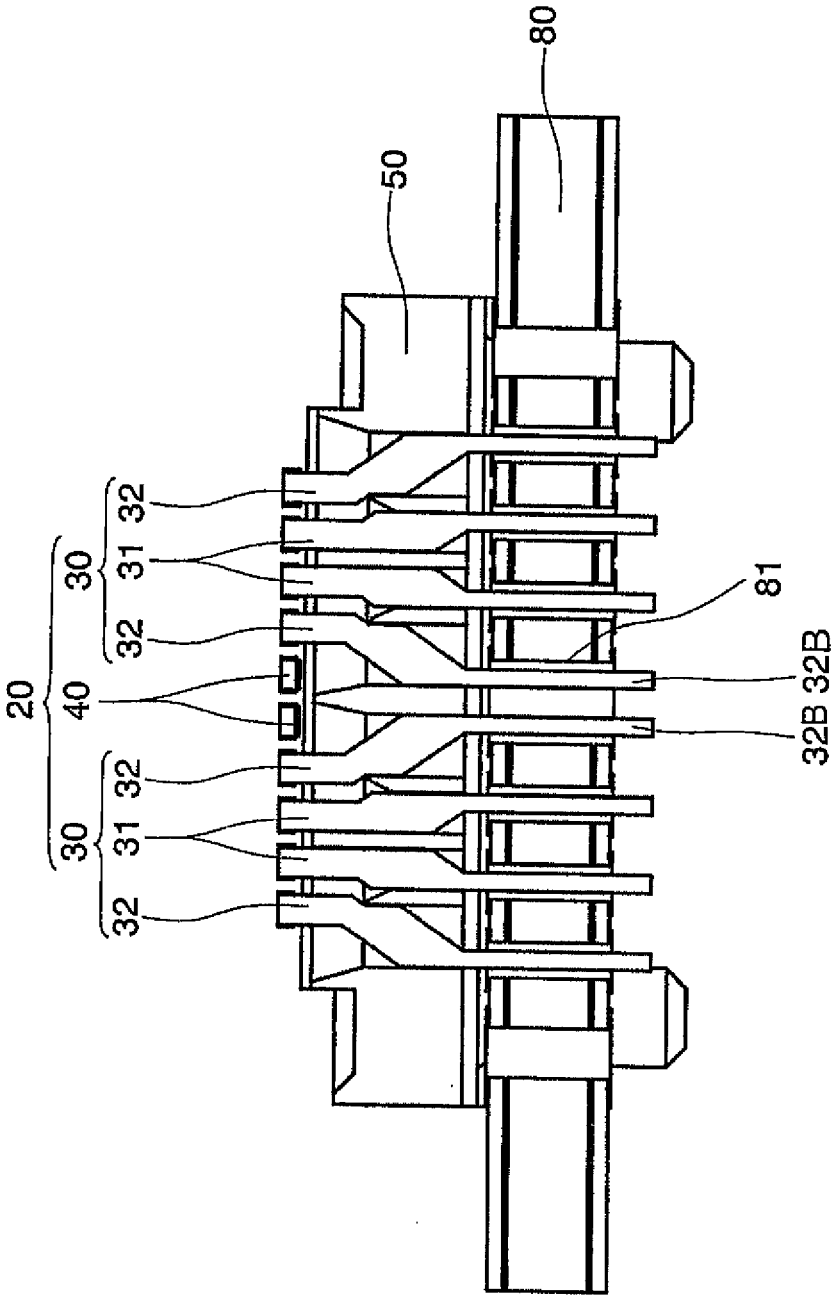

FIG. 8

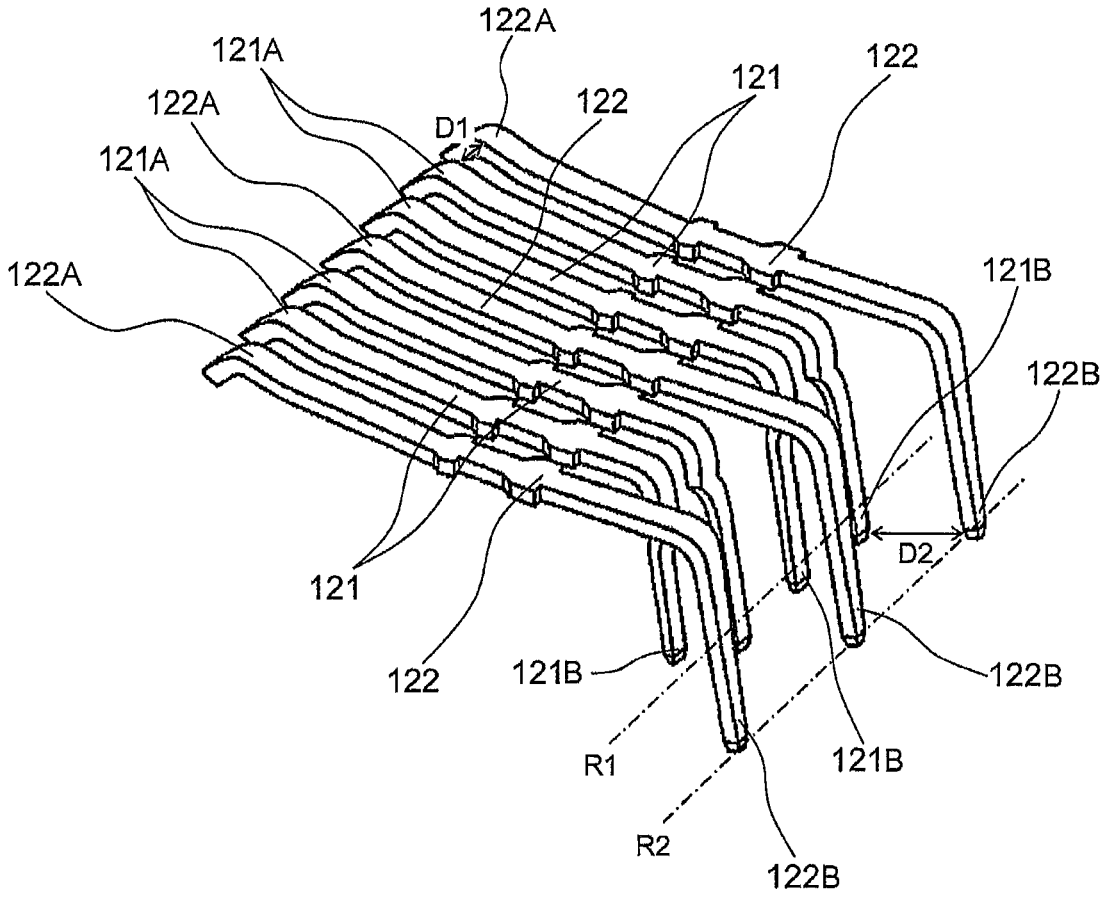

FIG. 9

Prior Art

CONNECTOR AND SIGNAL TRANSMISSION METHOD USING THE SAME

This application is based upon and claims the benefit to priority from Japanese patent application No. 2013-029400, filed on Feb. 18, 2013, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a connector and a signal transmission method using the same and, in particular, to a differential signal connector for use in connecting transmission lines for transmitting a differential signal pair and a signal transmission method using the differential signal connector.

2. Description of Related Art

There is known a differential transmission method of transmitting a differential signal pair comprising a pair of opposite-phase signals on paired two signal lines. The differential transmission method is capable of achieving high-speed data transmission and, therefore, is recently put into practical use in various fields.

For example, in case where the differential transmission method is used in data transmission between a device and a liquid crystal display, each of the device and the liquid crystal display is provided with a display port connector designed in conformity with a display port standard. As the display port standard, VESA Display Port Standard 1.0 and Version 1.1a thereof are known.

The display port connector is one type of a differential signal connector and has a first connection side for connection with a connecting object and a second connection side for connection with a printed board of the device or the liquid crystal display. The first connection side has a structure strictly determined by the display port standard because of the relationship with the connection object. On the other hand, the second connection side has a structure which is relatively free. The differential signal connector of the type is disclosed in Japanese Patent No. 4439540 (Patent Document 1) (corresp. to US2008/0014803A1).

As illustrated in FIG. **9**, the connector disclosed in Patent Document 1 has, as a lower contact group, two pairs of signal contacts **121** and a plurality of ground contacts **122** arranged on opposite sides of each pair of the signal contacts **121**.

On the first connection side, contacting portions **121**A of the signal contacts **121** and contacting portions **122**A of the ground contacts **122** are arranged in a single row at a predetermined distance D1 from one another, as shown in FIG. **9**.

On the second connection side, terminal portions **121**B of the signal contacts **121** are arranged in a first row R1 while terminal portions **122**B of the ground contacts **122** are arranged in a second row R2 which is shifted from the first row R1.

With the above-mentioned arrangement, a distance D2 between the terminal portions **121**B and **122**B is greater than the distance D1 between the contacting portions **121**A and **122**A. Thus, it is intended to simultaneously achieve reduction in size of the connector and good mountability of the terminal portions **121**B and **122**B to through holes (not shown) which require a predetermined size and an arrangement at a predetermined distance.

However, in the connector disclosed in Patent Document 1, the terminal portions **121**B of the signal contacts **121** and the terminal portions **122**B of the ground contacts **122** are arranged in the different rows R1 and R2, respectively, and the distance D2 between the terminal portions **121**B and **122**B is wide. Therefore, characteristic impedances around the terminal portions **121**B and **122**B are higher than those around the other portions. In this event, characteristic impedance matching is difficult to achieve. This results in a problem that high-speed signal transmission (for example, transmission of 10 Gbps or higher-speed signals containing a frequency component at which it is appropriate to treat a connector or a contact as a distribution constant circuit) is difficult.

SUMMARY OF THE INVENTION

In order to solve the above-mentioned problem in the related art, it is an object of this invention to provide a connector which is capable of simultaneously achieving reduction in size of the connector and good mountability of the connector to a mounting object and which allows easy matching of characteristic impedances and is therefore excellent in high-speed signal transmission characteristic.

It is another object of this invention to provide a signal transmission method using the above-mentioned connector.

A connector of an aspect of the present invention is mounted to a mounting object and connected to a connecting object. The connector comprises: a plurality of high-speed differential signal lanes (GSSG) each of which is composed of two first contacts (S) adapted to high-speed differential signal transmission and arranged adjacent to each other and two ground contacts (G) sandwiching the two first contacts and arranged on opposite sides of the two first contacts, one on each side; and at least one second contact which is disposed between adjacent ones of the high-speed differential signal lanes and which does not belong to the high-speed differential signal lanes. Each of the first contacts, the ground contacts, and the second contact has a contacting portion to be connected to the connecting object and a terminal portion to be connected to a mounting object. The connector has a first connection side for connection with the connecting object, where the contacting portions of the first contacts, the contacting portions of the ground contacts, and the contacting portion of the second contact are arranged in a single row at a distance from one another. The connector has a second connection side for connection with the mounting object, where the terminal portions of the first contacts and the terminal portions of the ground contacts are arranged in a first row at a distance wider than that between the contacting portions while the terminal portion of the second contact is arranged in a second row different from the first row. According to this configuration of the connector, the above-mentioned objects are achieved.

A connector of another aspect of the present invention is mounted to a mounting object and connected to a connecting object. The connector comprising: a plurality of high-speed differential signal lanes each of which is composed of two first contacts arranged adjacent to each other and two ground contacts sandwiching the two first contacts and arranged on opposite sides of the two first contacts, one on each side; and at least one second contact which is disposed between adjacent ones of the high-speed differential signal lanes. Each of the first contacts, the ground contacts, and the second contact has a contacting portion to be connected to the connecting object and a terminal portion to be connected to a mounting object. Each of the first contacts is a contact for transmitting a high-speed electric signal containing a frequency component corresponding to a wavelength λ satisfying $L>(\lambda/20)$ where L represents a length of the first contact from the contacting portion to the terminal portion. The second contact is a contact used when a signal to be transmitted does not

contain a frequency component corresponding to a wavelength λ satisfying M>(λ/20) where M represents a length of the second contact from the contacting portion to the terminal portion. The connector has a first connection side for connection with the connecting object, where the contacting portions of the first contacts, the contacting portions of the ground contacts, and the contacting portion of the second contact are arranged in a single row at a distance from one another. The connector has a second connection side for connection with the mounting object, where the terminal portions of the first contacts and the terminal portions of the ground contacts are arranged in a first row at a distance wider than that between the contacting portions while the terminal portion of the second contact is arranged in a second row different from the first row. According to this configuration of the connector, the above-mentioned objects are achieved.

The terminal portions of the ground contacts sandwiching the second contact and arranged on opposite sides of the second contact may be combined with each other to form an integral structure.

Each of the first contacts and the ground contacts may have a distance changing portion for changing a distance between adjacent ones of the first contacts and the ground contacts from a distance between the contacting portions into a distance between the terminal portions. In this case, the distance changing portion may have a contact width wider than that of each of the contacting portions and the terminal portions.

Each of the high-speed differential signal lanes may have a symmetrical structure with respect to a plane between the two first contacts of the high-speed differential signal lane.

A plurality of the second contacts may be arranged between the high-speed differential signal lanes. In this case, the second contacts arranged between the high-speed differential signal lanes may be formed so that the distance between the terminal portions is wider than that between the contacting portions.

The first and the second rows may be parallel to each other.

The second contact may be one of a control signal contact, a power supply contact, a ground contact, or a signal transmission contact which does not belong to the high-speed differential signal lanes, for example a signal transmission contact for transmitting signals at some Mbps.

According to a signal transmission method of an aspect of the present invention, high-speed differential signal transmission is carried out by mounting one of the connectors to a board in order to achieve the object of the invention.

In the connector according to this invention, the terminal portions of the first contacts and the ground contacts are arranged in the same first row while the terminal portions of the second contacts are shifted in the second row. Therefore, the distance between adjacent ones of the terminal portions of the first contacts and the ground contacts can be widened correspondingly. Thus, it is possible to simultaneously achieve reduction in size of the connector and good mountability of the connector to a mounting object and to easily obtain matching of characteristic impedances so as to improve high-speed signal transmission characteristics.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a connector according to a first embodiment of this invention in the state where it is used;

FIG. **2** is an exploded perspective view of the connector illustrated in FIG. **1**;

FIG. **3** is a perspective view of a lower contact group of the connector;

FIG. **4** is a perspective view showing the state where a lower contact assembly of the connector is mounted to a printed board;

FIG. **5** is a sectional view taken along a line A-A in FIG. **4** as seen in an arrow direction;

FIG. **6** is a plan view of the connector mounted to the printed board, as seen from a lower surface side of the printed board;

FIG. **7** is a perspective view of a lower contact group to be incorporated into a connector according to a second embodiment of this invention;

FIG. **8** is a sectional view similar to FIG. **5** and showing the state where a lower contact assembly of a connector according to a third embodiment of this invention is mounted to a printed board; and

FIG. **9** is a perspective view of a lower contact group to be incorporated into a conventional connector.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now, embodiments of a connector according to this invention will be described with reference to the drawings.

In the following description, a first direction A1 represents a direction in which a plurality of contacts are arranged. A second direction A2 is perpendicular to the first direction A1 and identical with a longitudinal direction of the contacts. A third direction A3 is perpendicular to the first and the second directions A1 and A2.

A connector **1** according to a first embodiment is a printed board mount connector adapted to be mounted to a printed board (mounting object) **80** and adapted to be fitted and connected to a mating connector (connecting object, not shown). In the following description, a front side of the connector **1** for connection with the mating connector (not shown) is called a first connection side while a bottom side of the connector **1** for connection with the printed board **80** is called a second connection side.

The printed board **80** used in this embodiment is a multilayer board. As shown in FIGS. **1** and **6**, the printed board **80** is provided with a number of through holes **81**. The printed board **80** has a lower surface **80**B provided with a plurality of lands **82**. Each of the lands **82** comprises a doughnut-shaped conductor pattern and is formed around an opening of each through hole **81**. From some of the lands **82**, a plurality of wiring patterns **84** are extracted along the printed board **80** in parallel to one another. Positions and functions of the through holes **81** will later become clear.

As seen from FIGS. **1** and **2**, the connector **1** comprises a lower contact assembly **10**, an upper contact assembly **60**, and a conductive shell **70** collectively covering the lower and the upper contact assemblies **10** and **60**.

As shown in FIG. **2**, the upper contact assembly **60** has an upper contact group **61** comprising a plurality of conductive contacts, and an insulating upper housing **62** holding the upper contact group **61**. As shown in FIGS. **1** and **2**, the upper housing **62** has a fitting protrusion **62**A adapted to be fitted to the mating connector (not shown) on the first connection side of the connector **1**. Each of the contacts of the upper contact group **61** has a front end arranged on an upper side of the fitting protrusion **62**A of the upper housing **62**, an intermediate portion extending rearward and then perpendicularly bent downward, and a lower end soldered to a wiring pattern **83** formed on an upper surface **80**A of the printed board **80** by a SMT (Surface Mount Technology) structure.

As shown in FIG. **1**, the shell **70** has a plurality of fixing legs **71** to be fixed to the printed board **80**. By soldering the fixing legs **71** to the printed board **80**, the connector **1** is fixed to the printed board **80**.

Next, the lower contact assembly **10** will be described in detail.

As shown in FIG. **2**, the lower contact assembly **10** has a lower contact group **20** comprising a plurality of conductive contacts **31**, **32**, and **40** (FIG. **3**), and an insulating lower housing **50** holding the lower contact group **20** with the conductive contacts **31**, **32**, and **40** kept in an aligned state.

In the following, the contacts **31**, **32**, and **40** may be referred to as the first contacts **31**, the ground contacts **32**, and the second contacts **40**, respectively.

As shown in FIG. **3**, the lower contact group **20** comprises two high-speed differential signal lanes **30** and the two second contacts **40** disposed between the two high-speed differential signal lanes **30**.

Each of the high-speed differential signal lanes **30** comprises the conductive contacts **31** and **32**, four in total. More in detail, as shown in FIG. **3**, each high-speed differential signal lane **30** comprises a pair of the first contacts **31**, two in number, arranged adjacent to each other and the ground contacts **32**, two in number, disposed on opposite sides of the pair of the first contacts **31**, one on each side. The ground contacts **32** are not limited to contacts exclusively for grounding but may be any contacts exhibiting an electric function equivalent to grounding when the high-speed differential signal lane **30** is formed. For example, power supply contacts may be used. The pair of the two first contacts **31** forms a differential signal pair for transmitting a high-speed differential signal (for example, 10 Gbps or higher-speed). Each of the first contacts **31** is adapted to transmit a high-speed electric signal containing a frequency component corresponding to a wavelength λ satisfying $L>(\lambda/20)$ where L represents a contact size of the first contact **31** (i.e., the length from a contacting portion **31**A to a terminal portion **31**B of the first contact **31**). In order to improve transmission characteristics of the high-speed differential signal lanes **30**, each of the high-speed differential signal lanes **30** has a symmetrical structure with respect to a plane between the two first contacts **31** of the high-speed differential signal lane **30** (i.e., a plane defined by the second direction A2 and the third direction A3).

The second contacts **40** do not belong to the high-speed differential lanes **30** (that is, the second contacts **40** are not for use in high-speed signal transmission). Specifically, the second contacts **40** may be control signal contacts, power supply contacts, ground contacts, or signal transmission contacts which do not belong to the high-speed differential signal lanes **30** (for example, signal transmission contacts for signal transmission at a speed on the order of Mbps). Each of the second contacts **40** is adapted to be used when a signal to be transmitted does not contain a frequency component corresponding to a wavelength λ satisfying $M>(\lambda/20)$ where M represents a contact size of the second contact **40** (i.e., the length from a contacting portion **40**A to a terminal portion **40**B of the second contact **40**). In this embodiment, the contact size L of the first contact **31** is designed to be equal or substantially equal to the contact size M of the second contact **40**.

As shown in FIG. **3**, the contacts **31**, **32**, and **40** of the lower contact group **20** have the contacting portions **31**A, **32**A, and **40**A to be connected to the mating connector (not shown), the terminal portions **31**B, **32**B, and **40**B to be connected to the printed board **80**, bent portions **31**C, **32**C, and **40**C formed between the contacting portions **31**A, **32**A, and **40**A and the terminal portions **31**B, **32**B, and **40**B, respectively, and distance changing portions **31**D, **32**D, and **40**D formed between the bent portions **31**C, **32**C, and **40**C and the terminal portions **31**B, **32**B, and **40**B, respectively.

On the first connection side of the connector **1**, the contacting portions **31**A, **32**A, and **40**A are arranged in a single row along the first direction A1 at a distance from one another and are disposed on a lower side of the fitting protrusion **62**A of the upper housing **62**.

As shown in FIG. **5**, the terminal portions **31**B, **32**B, and **40**B are inserted into the through holes **81** of the printed board **80** on the second connection side of the connector **1** and connected to the lands **82** by soldering on the lower surface **80**B of the printed board **80**.

As shown in FIG. **3**, the terminal portions **31**B and **32**B of the first contacts **31** and the ground contacts **32** are arranged in the first row R1 along the first direction A1 at a distance from one another. On the other hand, the terminal portions **40**B of the two second contacts **40** are arranged in the second row R2 shifted rearward from the first row R1 in the second direction A2 at a distance from one another, as shown in FIG. **3**.

The bent portions **31**C, **32**C, and **40**C are formed by perpendicularly bending the contacts **31**, **32**, and **40**, respectively. It is noted here that bending angles of the bent portions **31**C, **32**C, and **40**C are not limited to 90°.

As shown in FIG. **3**, the first contacts **31** and the ground contacts **32** have the distance changing portions **31**D and **32**D formed between the bent portions **31**C and **32**C and the terminal portions **31**B and **32**B, respectively. With this structure, the distance between adjacent ones of the terminal portions **31**B and **32**B of the first contacts **31** and the ground contacts **32** is widened, as compared with the distance between adjacent ones the contacting portions **31**A and **32**A of the first contacts **31** and the ground contacts **32**, so as to be matched with the distance between adjacent ones of the through holes **81** on the printed board **80**. As shown in FIG. **3**, each of the second contacts **40** has the distance changing portion **40**D formed between the bent portion **40**C and the terminal portion **40**B. With this structure, the distance between the terminal portions **40**B of the two second contacts **40** is widened, as compared with the distance between the contacting portions **40**A of the two second contacts **40**, so as to be matched with the distance between the through holes **81**. As shown in FIG. **3**, the distance changing portions **31**D, **32**D, and **40**D have contact widths wider than those of the remaining portions of the contacts **31**, **32**, and **40** so as to facilitate matching of the characteristic impedances.

The lower housing **50** holds the lower contact group **20** in an aligned state and, as shown in FIG. **1**, has positioning bosses **51** formed on its lower surface to position the connector **1** with respect to the printed board **80**.

In the connector **1** according to the first embodiment described above, the terminal portions **31**B and **32**B of the first contacts **31** and the ground contacts **32** are arranged in the first row R1 while the terminal portions **40**B of the second contacts **40** are arranged in the second row R2. Thus, the distance between adjacent ones of the terminal portions **31**B and **32**B of the first contacts **31** and the ground contacts **32** is wider than that between adjacent ones of the contacting portions **31**A and **32**B of the first contact **31** and the ground contacts **32**.

Thus, the terminal portions **31**B and **32**B of the first contacts **31** and the ground contacts **32** are arranged in the same first row R1 while the terminal portions **40**B of the second contacts **40** are shifted to the second row R2. Therefore, the

distance between adjacent ones of the terminal portions **31**B and **32**B of the first contacts **31** and the ground contacts **32** is widened correspondingly.

As a result, it is possible to simultaneously achieve reduction in size of the connector **1** and good mountability of the connector **1** to the printed board **80** and to easily obtain matching of characteristic impedances of the first contacts **31** and the ground contacts **32** so as to improve high-speed signal transmission characteristics.

Next referring to FIG. **7**, a second embodiment of this invention will be described. In the following, a difference from the first embodiment will only be described and components similar in function to those of the first embodiment are designated by the same reference symbols.

In the second embodiment of this invention, the terminal portions **32**B of the ground contacts **32** sandwiching the pair of the second contacts **40** and arranged on opposite sides of the pair of the second contacts **40** are combined with each other to form an integral structure, as shown in FIG. **7**.

In the second embodiment described above, the two ground contacts **32** are combined into a single component. With this structure, the number of components is reduced. In addition, the number of the through holes **81** of the printed board **80** for insertion of the terminal portions **32**B of the ground contacts **32** is reduced and the number of times of soldering during mounting of the connector **1** to the printed board **80** is reduced also. Thus, it is possible to reduce a load imposed during manufacture and mounting of the connector **1**.

Next referring to FIG. **8**, a third embodiment of this invention will be described. In the following, a difference from the first embodiment will only be described and components similar in function to those of the first embodiment are designated by the same reference symbols.

In the third embodiment, the terminal portions **32**B of the ground contacts **32** sandwiching the pair of the second contacts **40** and arranged on the opposite sides of the pair of the second contacts **40** are inserted into a common through hole **81** of the printed board **80**, as shown in FIG. **8**.

In the third embodiment described above, the number of the through holes **81** of the printed board **80** for insertion of the terminal portions **32**B of the ground contacts **32** is reduced and the number of times of soldering during mounting of the connector **1** to the printed board **80** is reduced also. Thus, it is possible to reduce a load imposed during manufacture and mounting of the connector **1**.

In the foregoing embodiments, description has been made about the case where the connector has two high-speed differential signal lanes each of which comprises the two first contacts and the two ground contacts. However, three or more high-speed differential signal lanes may be provided. In this event, the second contacts are disposed between every adjacent ones of the high-speed differential signal lanes.

In the foregoing embodiments, the number of the second contacts arranged between the high-speed differential signal lanes is equal to two. However, the number of the second contacts arranged between the high-speed differential signal lanes may be any number not smaller than one.

In the foregoing embodiments, the terminal portions of the first contacts and the ground contacts are arranged in the first row located frontward in the second direction than the second row in which the terminal portions of the second contacts are arranged. Alternatively, the terminal portions of the first contacts and the ground contacts may be arranged rearward in the second direction than the terminal portions of the second contacts.

What is claimed is:

1. A connector to be mounted to a mounting object and connected to a connecting object, the connector comprising:

a plurality of high-speed differential signal lanes, each signal lane of the plurality of high-speed differential signal lanes being composed of two first contacts adapted to high-speed differential signal transmission and arranged adjacent to each other and two ground contacts sandwiching the two first contacts and arranged on opposite sides of the two first contacts, one on each side; and

at least one second contact disposed between adjacent ones of the high-speed differential signal lanes and not belonging to the high-speed differential signal lanes;

each of the first contacts, the ground contacts, and the second contact having a contacting portion to be connected to the connecting object and a terminal portion to be connected to the mounting object;

the connector having a first connection side for connection with the connecting object, where the contacting portions of the first contacts, the contacting portions of the ground contacts, and the contacting portion of the second contact are arranged in a single row at a contacting distance from one another;

the connector having a second connection side for connection with the mounting object, where the terminal portions of the first contacts and the terminal portions of the ground contacts are arranged in a first row at a terminal distance from one another, the terminal distance being wider than the contacting distance, while the terminal portion of the second contact is arranged in a second row different from the first row.

2. The connector according to claim **1**, wherein the terminal portions of the ground contacts sandwiching the second contact and arranged on opposite sides of the second contact are combined with each other to form an integral structure.

3. The connector according to claim **1**, wherein:

each of the first contacts and the ground contacts has a distance changing portion for changing a distance between adjacent ones of the first contacts and the ground contacts from the contacting distance into the terminal distance;

the distance changing portion having a first contact width, the contacting portions having a second contact width, and the terminal portions having a third contact width, the first contact width being wider than the second contact width and being wider than the the third contact width.

4. The connector according to claim **1**, wherein each of the high-speed differential signal lanes has a symmetrical structure with respect to a plane between the two first contacts of the high-speed differential signal lane.

5. The connector according to claim **1**, wherein:

a plurality of the second contacts are arranged between the high-speed differential signal lanes;

the second contacts arranged between the high-speed differential signal lanes being formed so that a second contact terminal distance is between the terminal portions of the second contacts and so that a second contact contacting distance is between the contacting portions of the second contacts, the second contact terminal distance being wider than the second contact contacting distance.

6. The connector according to claim **1**, wherein the first and the second rows are parallel to each other.

7. The connector according to claim **1**, wherein the second contact is one of a control signal contact, a power supply

contact, a ground contact, or a signal transmission contact not belonging to the high-speed differential signal lanes.

8. A signal transmission method of carrying out high-speed differential signal transmission by mounting a connector according to claim **1** to a board.

9. A connector to be mounted to a mounting object and connected to a connecting object, the connector comprising:

a plurality of high-speed differential signal lanes, each signal lane of the plurality of high-speed differential signal lanes being composed of two first contacts arranged adjacent to each other and two ground contacts sandwiching the two first contacts and arranged on opposite sides of the two first contacts, one on each side; and

at least one second contact disposed between adjacent ones of the high-speed differential signal lanes;

each of the first contacts, the ground contacts, and the second contact having a contacting portion to be connected to the connecting object and a terminal portion to be connected to the mounting object;

each of the first contacts being a contact for transmitting a high-speed electric signal containing a frequency component corresponding to a wavelength λ satisfying $L>(\lambda/20)$ where L represents a length of the first contact from the contacting portion to the terminal portion;

the second contact being a contact used when a signal to be transmitted does not contain a frequency component corresponding to a wavelength λ satisfying $M>(\lambda/20)$ where M represents a length of the second contact from the contacting portion to the terminal portion;

the connector having a first connection side for connection with the connecting object, where the contacting portions of the first contacts, the contacting portions of the ground contacts, and the contacting portion of the second contact are arranged in a single row at a contacting distance from one another;

the connector having a second connection side for connection with the mounting object, where the terminal portions of the first contacts and the terminal portions of the ground contacts are arranged in a first row at a terminal distance from one another, the terminal distance being wider than the contacting distance, while the terminal portion of the second contact is arranged in a second row different from the first row.

10. The connector according to claim **9**, wherein the terminal portions of the ground contacts sandwiching the second contact and arranged on opposite sides of the second contact are combined with each other to form an integral structure.

11. The connector according to claim **9**, wherein:

each of the first contacts and the ground contacts has a distance changing portion for changing a distance between adjacent ones of the first contacts and the ground contacts from the contacting distance into the terminal distance;

the distance changing portion having a first contact width, the contacting portions having a second contact width, and the terminal portions having a third contact width, the first contact width being wider than the second contact width and being wider than the third contact width.

12. The connector according to claim **9**, wherein each of the high-speed differential signal lanes has a symmetrical structure with respect to a plane between the two first contacts of the high-speed differential signal lane.

13. The connector according to claim **9**, wherein:

a plurality of the second contacts are arranged between the high-speed differential signal lanes;

the second contacts arranged between the high-speed differential signal lanes being formed so that a second contact terminal distance is between the terminal portions of the second contacts and so that a second contact contacting distance is between the contacting portions of the second contacts, the second contact terminal distance being wider than the second contact contacting distance.

14. The connector according to claim **9**, wherein the first and the second rows are parallel to each other.

15. The connector according to claim **9**, wherein the second contact is one of a control signal contact, a power supply contact, a ground contact, or a signal transmission contact not belonging to the high-speed differential signal lanes.

16. A signal transmission method of carrying out high-speed differential signal transmission by mounting a connector according to claim **9** to a board.

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